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(54) [Title of the Invention]

METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE, AND LIQUID CRYSTAL DISPLAY DEVICE

(57) [Abstract]

[Object]

Temperature distribution inside an annealed portion at the time of annealing is uniformed, and crystal grain diameter after annealing is uniformed.

[Structure]

A plastic film 4 is placed in a CVD chamber, and substrate temperature is set to be at room temperature. Next, a vicinity of a surface of the plastic film 4 is irradiated with an ArF laser 2 to deposit an amorphous silicon 3. The plastic film 4 is transferred to an ablation chamber, laser diameter of the ArF laser 2 is adjusted, and the plastic film 4 is irradiated with the ArF laser 2, and thus a sapphire 5 is deposited on the plastic film 4 by photochemical ablation. Then, the sapphire 5 is irradiated with the ArF laser 2 with keeping the substrate temperature of the plastic film 4 at room temperature. The laser energy is not much absorbed in the sapphire 5 but in the amorphous silicon 3, and the amorphous silicon 3 is crystallized to be a crystallized silicon 6. Thereafter, a MOS transistor is formed.

[Scope of Claim]

[Claim 1]

A method for manufacturing a semiconductor device in which a thin film transistor is formed on a plastic film, characterized in that a thin film having a range of thermal conductivity (K) of $K \geq 0.03$ (cal/cm·s·°C) and a transmissivity (T) of a laser for crystallization of $T \geq 80\%$ is formed in advance on a semiconductor thin film when the semiconductor thin film is formed on the plastic film and the semiconductor thin film is irradiated with a pulsed laser to perform crystallization of the semiconductor thin film.

[Claim 2]

The method for manufacturing a semiconductor device according to Claim 1, characterized in that a ceramic insulating material is used for the thin film on the semiconductor thin

film.

[Claim 3]

The method for manufacturing a semiconductor device according to Claim 2, characterized in that the ceramic insulating material is used for a gate insulating film of a thin film transistor.

[Claim 4]

The method for manufacturing a semiconductor device according to Claim 2, characterized in that the ceramic insulating material is formed by a laser ablation method, an excimer laser is used for the laser, and a target is irradiated with laser having laser energy of 10 mJ/cm^2 to 1 J/cm^2 and a number of shot of 1 to 100, as a condition of the laser.

[Claim 5]

The method for manufacturing a semiconductor device according to Claim 1, characterized in that the semiconductor thin film on the plastic film and the thin film on the semiconductor thin film are formed in a same system by light energy.

[Claim 6]

A liquid crystal display device characterized in that the thin film transistor described in Claim 1 is used for driving a display portion for a liquid crystal display.

[Detailed Description of the Invention]

[0001]

[Technical Field]

The present invention relates to a method for manufacturing a semiconductor device, and a liquid crystal display device, and in more detail, relates to a method for manufacturing a semiconductor device in which a thin film transistor is formed on a substrate with low heat resistance, and a liquid crystal display device in which the thin film transistor is used for a display portion for a liquid crystal display. For example, it is applied to a drive element for a MOS (Metal Oxide Semiconductor) transistor, a C (Complementary) MOS transistor, a bipolar transistor, and an LCD (Liquid Crystal Device).

[0002]

[Prior Art]

Conventionally, in a method for forming a high performance thin film transistor (TFT;

Thin Film Transistor) on a substrate with low heat resistance, there is a method in which a semiconductor thin film is formed on a substrate, and the semiconductor thin film becomes a polycrystalline semiconductor layer in which its crystal grain diameter is increased, in other words a semiconductor crystalline layer, by using irradiation annealing (anneal; heat treatment) utilizing outermost surface workability of pulsed light energy, and a TFT is formed at the layer. However, a semiconductor thin film is melted and solidified in a short time with annealing by the pulsed light energy; therefore there has been a problem in that crystal grain diameter after annealing is not uniform due to generation of random crystal nuclei and nonuniformity of temperature distribution inside an annealed portion because of the in-plane nonuniformity of the pulsed light energy.

[0003]

As for a semiconductor device in which an element is formed on a semiconductor substrate, an element is normally arranged in a planar form (2-dimensional) on a silicon substrate by oxidization, diffusion, ion implantation, photo-etching and the like. However, the element is required to be formed on a multilayer of 2 or more layers; therefore, a so-called stacked layer semiconductor device (3-dimensional IC) which highly integrates and speeds up the semiconductor device by creating smaller elements, is proposed. In order to realize the 3-dimensional IC, for example an insulating film such as SiO_2 or SiN covers on the silicon substrate, a polycrystalline silicon thin film is deposited thereon, irradiation annealing with laser light of continuous beam or electron beam is performed to the polycrystalline silicon thin film to form a single crystalline silicon layer, and by forming an element in the layer, the stacked layer semiconductor device is manufactured. However, a conventional beam annealing method can only make crystal grain diameter from 20 to 30 [μm] at the largest, and there are a large number of dislocation, and defects of polycrystal and a stacked layer in a recrystallized silicon crystalline layer, and therefore the crystallinity of the silicon crystalline layer is extremely bad. In order to solve this point, for example "a method for manufacturing a semiconductor thin film crystalline layer" is proposed in Japanese Patent Laid-Open No. S60-54426. According to this patent bulletin, annealing is attempted to be uniform as well as irradiation damage at the time of beam annealing is attempted to be suppressed, by forming a high melting point metal film on a

semiconductor thin film which should be annealed.

[0004]

[Object]

The present invention is made in view of the situations as described above. It is an object of the present invention to provide a method for manufacturing a semiconductor device, and a liquid crystal display device which can make temperature distribution inside an annealed portion and crystal grain diameter after annealing uniform, by forming a thin film having high transmissivity of a laser for conducting the annealing and high thermal conductivity on a semiconductor thin film.

[0005]

[Structure]

In order to achieve the above-described object, the present invention is characterized in that (1) in a method for manufacturing a semiconductor device in which a thin film transistor (TFT) is formed on a plastic film, a film having a range of thermal conductivity (K) of $K \geq 0.03$ (cal/cm·s·°C) and transmissivity (T) of a laser for crystallization of $T \geq 80\%$ is formed in advance on a semiconductor thin film when the semiconductor thin film is formed on the plastic film and the semiconductor film is irradiated with a pulsed laser to perform crystallization of the semiconductor thin film, further (2) a ceramic insulating material is used for a thin film on the semiconductor thin film, further (3) in the above-described (2), the ceramic insulating material is used for a gate insulating film of the thin film transistor, further (4) in the above-described (2), the ceramic insulating material is formed by a laser ablation method, an excimer laser is used for the laser, and a target is irradiated with laser having laser energy of 10 mJ/cm^2 to 1 mJ/cm^2 and the number of shots of 1 to 100, as a condition of the laser, further (5) in the above-described (1), the semiconductor thin film on the plastic film and the thin film on the semiconductor thin film are formed in the same system by light energy, further (6) in the above-described (1), the thin film transistor is used for a display portion for a liquid crystal display. Hereinafter, description will be given based on an embodiment of the present invention.

[0006]

As for the present invention, in a method for forming a high performance TFT on a

substrate with low heat resistance, forming a semiconductor thin film having high transmissivity of a laser for conducting annealing and high thermal conductivity on the semiconductor thin film, enables temperature distribution inside an annealed portion at the time of annealing and crystal grain diameter after annealing to be uniform. However, by using a ceramic insulating material for a thin film on the semiconductor thin film, this can be used as a gate insulating film, and an interface between the semiconductor thin film and the gate insulating film can be clean, and thus characteristics of a TFT element can be stable. Material characteristics of the ceramic insulating material are shown in Chart 1.

[0007]

[CHART 1]

Material characteristic of ceramic insulating materials

	sapphire	99% alumina	spinel
thermal conductivity (cal/cm·s·°C)	0.065	0.060	0.035
specific resistance (Ω·cm) at 20 °C	10^{15}	$>10^{14}$	$>10^{14}$
transmissivity	80 %min (0.24~6.0 μm)	————	80 %min (0.24~6.0 μm)

[0008]

FIGS. 1(a) to (d) are process drawings to describe one embodiment of a method for manufacturing a semiconductor device according to the present invention. In the drawing, reference numeral 1 denotes ambient gas; 2, a laser; 3, an amorphous silicon; 4, a plastic substrate; 5, a sapphire; 6, a crystallized silicon; 7, a gate electrode; 8a, a source electrode; 8b, a drain electrode; and 9, an interlayer insulating film. In addition, FIG. 2 is a block diagram of a manufacturing device of a semiconductor device according to the present invention. In the drawing, reference numeral 21 denotes a chemical cylinder; 22, a laser; 23a, a CVD (Chemical Vapor Deposition) annealing optical system; 23b, an ablation optical system; 24, a quartz window; 25, a partition window; 26, a CVD annealing window; 27, a target; 28, an ablation chamber; and 29, an exhaust system.

[0009]

Hereinafter, the description will be given based on FIG. 1 and FIG. 2. (1) A process of FIG. 1(a): The plastic film 4 having a length of 50 mm on a side is placed in the CVD chamber 21, and substrate temperature is set to be at room temperature. Next, a treatment chamber 21 is made to be disilane (Si_2H_6) atmosphere, and a vicinity of a surface of the plastic film 4 is irradiated with an ArF laser 2 in which laser diameter is set to be 30 mm on a side by the optical system 23a, and the amorphous silicon 3 is deposited. The condition of deposition is Si_2H_6 flow of 10 sccm, gas pressure of 0.5 torr, and laser power of 200 mJ/cm^2.

[0010]

(2) A process of FIG. 1(b): Next, the plastic film 4 is transferred to the ablation chamber 28, laser diameter of the ArF laser 2 is adjusted by the optical system 23b, and the target 27 is irradiated with the ArF laser 2, and the sapphire (α-Al_2O_3) 5 is deposited on the plastic film 4. An Ablation condition is laser power of 300 mJ/cm^2 and the number of shots of 20.

[0011]

(3) A process of FIG. 1(c): The plastic film 4 is again transferred to the treatment chamber 21, and the sapphire (α-Al_2O_3) 5 is irradiated with the ArF laser 2 in which laser diameter is set to be 20 mm on a side by the optical system 23a, with keeping substrate temperature at room temperature. Then, the laser energy is not much absorbed in the sapphire (α-Al_2O_3) 5 but in the amorphous silicon 3. In this step, the amorphous silicon 3 is crystallized to be the crystallized silicon 6.

(4) A step of FIG. 1(d): After that, a MOS transistor was formed. In other words, the sapphire (α-Al_2O_3) 5 on the crystallized silicon 6 is patterned to form a gate insulating film, and after the gate electrode film 11 is formed, the MOS transistor was formed through a predetermined process.

[0012]

Ultraviolet ray such as an excimer laser has large absorption coefficient of the semiconductor thin film as described above. Most of the laser light is absorbed in a vicinity of an interface between the above-described semiconductor thin film and the ceramic insulating material, and the temperature is increased locally, and thus it is possible

to crystallize the semiconductor thin film. As described above, since the semiconductor thin film surface layer is locally heated, thermal damage to the plastic film, which is a base substrate, can be suppressed. In addition, by using a thin film ceramic insulating material on the semiconductor thin film, it can be used as a gate insulating film of a TFT, and thus the process is simplified, and it is expected that the interface characteristic between the semiconductor thin film and the ceramic insulating material is improved at the time of annealing. In other words, by the crystal grain diameter becoming uniform and the improvement of the interface characteristic, there are hopes for improvement in TFT characteristics. When a TFT element is used for a drive element of an LCD, response speed of an LCD image becomes fast, and quality as the LCD is improved.

[0013]

[Effect of the Invention]

As is clear from the above description, there are following effects according to the present invention.

(1) An effect for Claim 1: In a method for forming a high performance TFT on a plastic film, forming a thin film having high transmissivity of a laser for conducting annealing and high thermal conductivity enables temperature distribution inside an annealed portion at the time of annealing and crystal grain diameter after annealing to be uniform.

(2) An effect for Claim 2: By using a ceramic insulating material for a thin film on the semiconductor thin film, even if it is locally subjected to high temperature, it can withstand high temperature, and the material characteristic is not spoiled.

(3) An effect for Claim 3: When the ceramic insulating material is used for a gate insulating film of a thin film transistor, it is a continuous process, and thus an interface between the semiconductor thin film and the gate insulating film is clean, and the interface characteristic is improved with the annealing process, and thus characteristic of a TFT element can be stable.

(4) An effect for Claim 4: When the ceramic insulating material is formed by a laser ablation method, an insulating material having favorable film quality can be obtained. In addition, an excimer laser is used for the laser, and a target is irradiated with laser having laser energy of 10 mJ/cm^2 to 1 J/cm^2 and the number of shots of 1 to 100 as the condition,

and thus a most suitable film quality can be obtained with this range of condition.
(5) An effect for Claim 5: Since the semiconductor thin film on the plastic film and the thin film on the semiconductor thin film are formed in the same system, with light energy, it is possible to suppress thermal damage to the plastic film due to low temperature, with laser.
(6) An effect for Claim 6: Since the thin film transistor is used for driving a display portion for a liquid crystal display, quality of a plastic film LCD can be improved.
[Brief Description of the Drawings]
[FIG. 1] A block diagram to describe one embodiment of a method for manufacturing a semiconductor device according to the present invention.
[FIG. 2] A block diagram of a manufacturing device of a semiconductor device according to the present invention.
[Explanation of Reference Number]
1 ambient gas
2 laser
3 amorphous silicon
4 plastic substrate
5 sapphire
6 crystallized silicon
7 gate electrode
8a source electrode
8b drain electrode
9 interlayer insulating film